

84726

TECHNICAL NOTE No. 1055

DECEMBER 1955

**Comparison Of Aerodynamic Characteristics
Of 20MM, HEI, T282EI Shell With Fuze
M505 And 20MM, HEI, T282EI Shell
With Fuze T32I**

EUGENE D. BOYER

DEPARTMENT OF THE ARMY PROJECT No. 5B03-07-002
ORDNANCE RESEARCH AND DEVELOPMENT PROJECT No. TB3-0426
(AIR)

BALLISTIC RESEARCH LABORATORIES



ABERDEEN PROVING GROUND, MARYLAND

Destroy when no longer
needed. DO NOT RETURN

BALLISTIC RESEARCH LABORATORIES

TECHNICAL NOTE NO. 1055

December 1955

COMPARISON OF AERODYNAMIC CHARACTERISTICS OF 20MM, HEI, T282E1 SHELL
WITH FUZE M505 AND 20MM, HEI, T282E1 SHELL WITH FUZE T321

Eugene D. Boyer

Department of the Army Project No. 5B03-07-002
Ordnance Research and Development Project No. TB3-0426 Air

ABERDEEN PROVING GROUND, MARYLAND

BALLISTIC RESEARCH LABORATORIES

TECHNICAL NOTE NO. 1055

EDBoyer/mjf
Aberdeen Proving Ground, Md.
December 1955

COMPARISON OF AERODYNAMIC CHARACTERISTICS OF 20MM, HEI, T282E1 SHELL
WITH FUZE M505 AND 20MM, HEI, T282E1 SHELL WITH FUZE T321

ABSTRACT

Comparison of the aerodynamic characteristics of the 20mm HEI, T282E1 shell with a standard M505 fuze and with a T321 fuze showed no significant difference at velocities where the presence of the arming ball rotor in the M505 fuze does not influence the dynamics. Above $M = 1.6$, the T282E1 shell with the T321 fuze behaves the same as with the M505 fuze with the rotor removed.

TABLE OF SYMBOLS AND COEFFICIENTS

A	axial moment of inertia (gram - in ²)
B	transverse moment of inertia (gram - in ²)
d	diameter in inches
K _D	Drag coefficient
K _H	Damping moment coefficient
K _N	Normal force coefficient
K _T	Magnus moment coefficient
K _M	Overturning moment coefficient
CP _N	Normal force center of pressure
M	Mach number
N	Number of yaw stations
N _T	Number of timing stations
m	Weight in grams
c.m.	Center of mass in calibers from base
l	Overall length in calibers
λ _{1,2}	Yaw damping rates
$\overline{\delta^2}$	Mean squared yaw (Degrees ²)
K _{D₀2}	Yaw drag coefficient
K _{D0}	Zero yaw drag coefficient
K _{1,2}	Magnitude of epicyclic yaw arms
S _L	Serve associated with the lift force
s	Gyroscopic stability factor
\overline{s}	Dynamic stability factor
ε _y	Error in yaw fit
ε _s	Error in serve fit

INTRODUCTION

Preparation of firing tables for a bullet fired from high speed aircraft and involving conditions of large yaw is a complicated matter. Therefore, it is very desirable, if possible, to spot check firing table entries by actual observations. This is difficult but could be done by accurately instrumented aircraft recording the initial conditions of the bullet's trajectory and exploding the bullet at a predetermined time so that both the aircraft and the explosion could be photographed from the ground. For the 20mm HEI, T282E1, shell this procedure required the development of a special time fuze. This has been done by the Bulova Watch Company and the fuze is designated as T321.

Our job was to compare the aerodynamic characteristics of the T282 shell with the T321 fuze relative to those of the same shell equipped with the standard M505 fuze. This note contains the results of such a comparison.

Ten rounds of shell with the T321 fuze were fired in the Aerodynamics Range at Mach numbers from 0.78 to 3.2. The characteristics of the T282E1 shell with M505 fuze are contained in Reference 1.

TREATMENT OF DATA

The aerodynamic coefficients are extracted from attitude, position, and time measurements of the shell by employing standard linearized reduction techniques². Table I gives the physical measurements for the shell with both fuzes. Table II lists the aerodynamic data for each round with the T321 fuze. The aerodynamic data for the shell with the M505 fuze can be found in Tables II and III of Reference 1.

Figures 1 through 8 compare the aerodynamic coefficients of the shell with the T321 fuze, with the M505 fuze, and with the modified* M505 fuze. The solid line represents the M505 fuze; the broken line, the modified M505 fuze. Since the modified fuze differed from the M505 fuze only in K_H and λ_1 , only Figures 6 and 7 have a broken line. The data for the T321 fuze are plotted as circled points.

* The arming ball rotor was removed from the fuze.

RESULTS

As was expected, the aerodynamic coefficients, other than K_H , of the shell do not change significantly by substituting the T321 fuze for the M505 fuze. Consequently, the sole purpose of Figures 1 through 5 (which plot K_{Do} , K_M , K_N , CP_N , and K_T , respectively, vs. Mach number) is to depict the aerodynamic similarity of both fuzes. For Figure 1, K_D was reduced to K_{Do} by the equation: $K_D = K_{Do} + K_{D\delta 2} \delta^2$. For the comparison of K_M values in Figure 2, it was necessary to compute the moment with the T321 fuze about the c.m. position of the M505 fuze shell.

Figure 6 shows the difference in observed K_H values between the two fuze types for varying Mach number. Above $M = 1.6$, K_H for the shell with the T321 fuze coincides with K_H with the modified M505 fuze, the unmodified M505 fuze shell having smaller K_H values.

Figures 7 and 8 show λ_1 and λ_2 , the yaw damping rates plotted vs. Mach number. The observed differences in K_H are naturally reflected in λ_1 ; these differences in K_H do not materially affect λ_2 .

Plate 1 is a photograph of the shell with both fuze types. Plate 2 is a shadowgraph of the T321 fuze shell in flight.

Eugene D. Boyer

EUGENE D. BOYER

TABLE I

Physical Measurements of 20mm, HEI, T282E1 Shell

	<u>Units</u>	<u>With M505</u> <u>Fuze</u>	<u>With T321</u> <u>Fuze</u>
m	grams	98.163	97.861
c.m.	calibers from base	1.566	1.536
A	gram - in ²	8.305	8.313
B	gram - in ²	62.56	59.43
ℓ	calibers	3.819	3.799
d	inches	.784	.784

TABLE II

AERODYNAMIC COEFFICIENTS

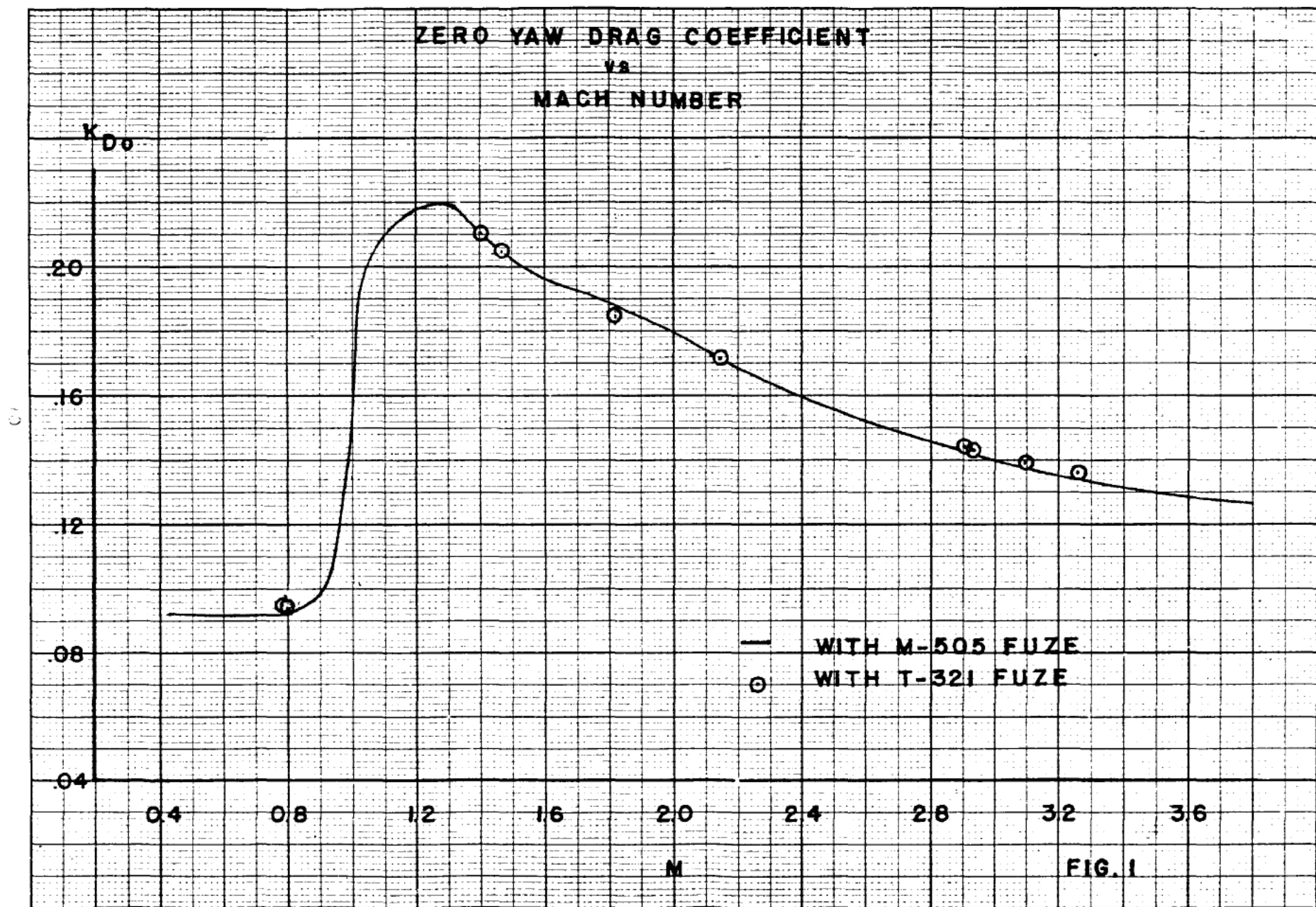
Rd No	M	δ^2	K_D	K_M	K_N	K_H	K_T	$\lambda_1 \times 10^3$	$\lambda_2 \times 10^3$	K_1	K_2	\bar{s}	s	N	N_T	ϵ_y	ϵ_s	S_L
3906*	.788	9.16	.0996							.003	.052				7			
3907**	.794	10.46	.0990	.991		-3.91	.43	-.91	-3.89	.014	.049	1.47	2.24	16	8	.0030		
3908	1.404	8.43	.2181	1.055	1.10	2.28	0	3.89	1.01	.033	.035	.54	2.25	26	7	.0014	.0076	.16
3909	1.460	2.94	.2078	1.046	1.10	2.02	-.01	3.25	1.30	.022	.017	.67	2.24	25	8	.0013	.0076	.08
3910	1.818	13.71	.1950	.962	1.13	2.56	-.05	3.47	1.87	.046	.042	.76	2.42	22	7	.0014	.0079	.24
3911	2.146	4.71	.1745	.899	1.16	2.35	-.03	3.36	1.67	.022	.029	.73	2.64	25	9	.0024	.0093	.21
3912	2.904	4.23	.1472	.744	1.11	1.91	-.06	2.24	2.09	.025	.024	.97	2.89	21	6	.0016	.0087	.23
3913	2.924	8.23	.1497	.770	1.11	1.80	-.04	2.28	1.83	.034	.034	.91	3.02	27	9	.0017	.0050	.34
3914	3.087	5.10	.1430	.762	1.08	1.84	-.06	2.08	2.13	.027	.026	1.01	3.02	26	8	.0012	.0069	.26
3915	3.257	3.31	.1379	.747	1.11	1.87	-.08	1.84	2.46	.022	.021	1.12	3.11	24	9	.0023	.0098	.23

* Nutational yaw arm too small for reduction.

** Since no satisfactory swerve reduction was obtained, K_H , K_T , and \bar{s} were computed by using K_N from Reference 1.

REFERENCES

1. Boyer, E. D., Aerodynamic Characteristics for Small Yaws of 20mm Shell, HEI, T282E1 With Fuze M505 For Mach Numbers .36 to 3.78, BRLM Report No. 916 (1955) (CONFIDENTIAL).
2. Murphy, C. H., Data Reduction for the Free Flight Spark Ranges, BRL Report No. 900 (1954).



MOMENT COEFFICIENT
vs
MACH NUMBER

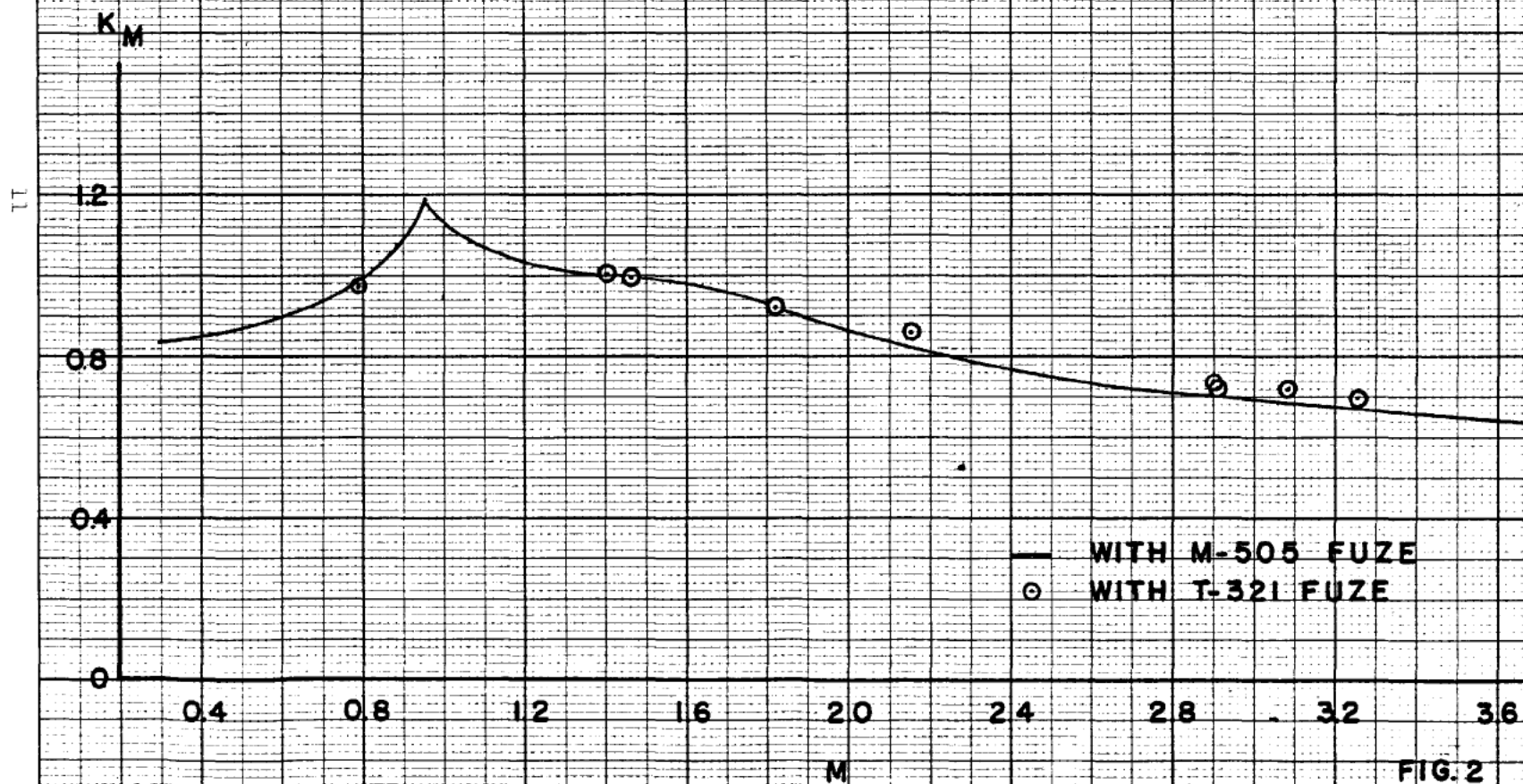


FIG. 2

NORMAL FORCE COEFFICIENT
VS
MACH NUMBER

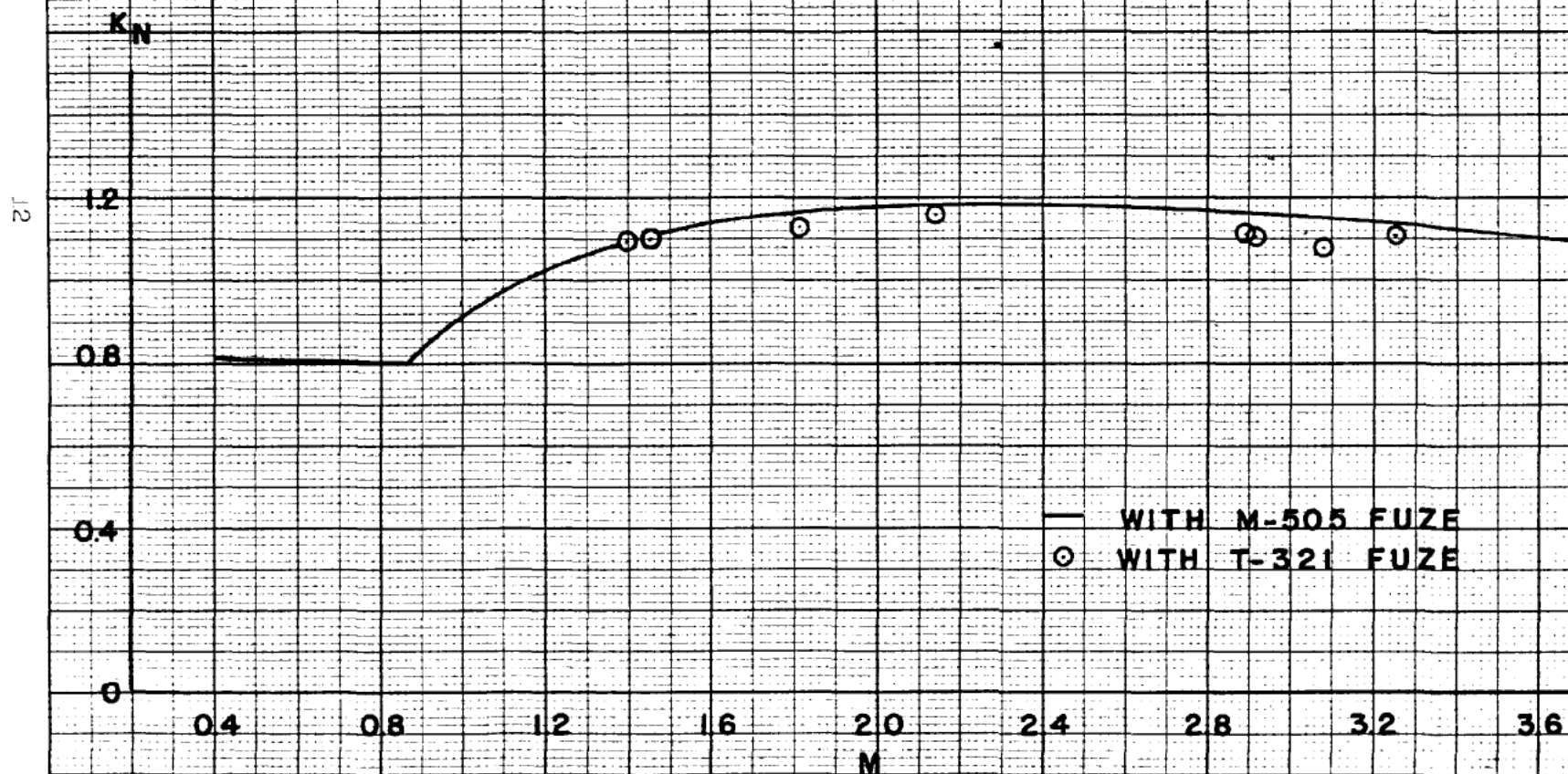
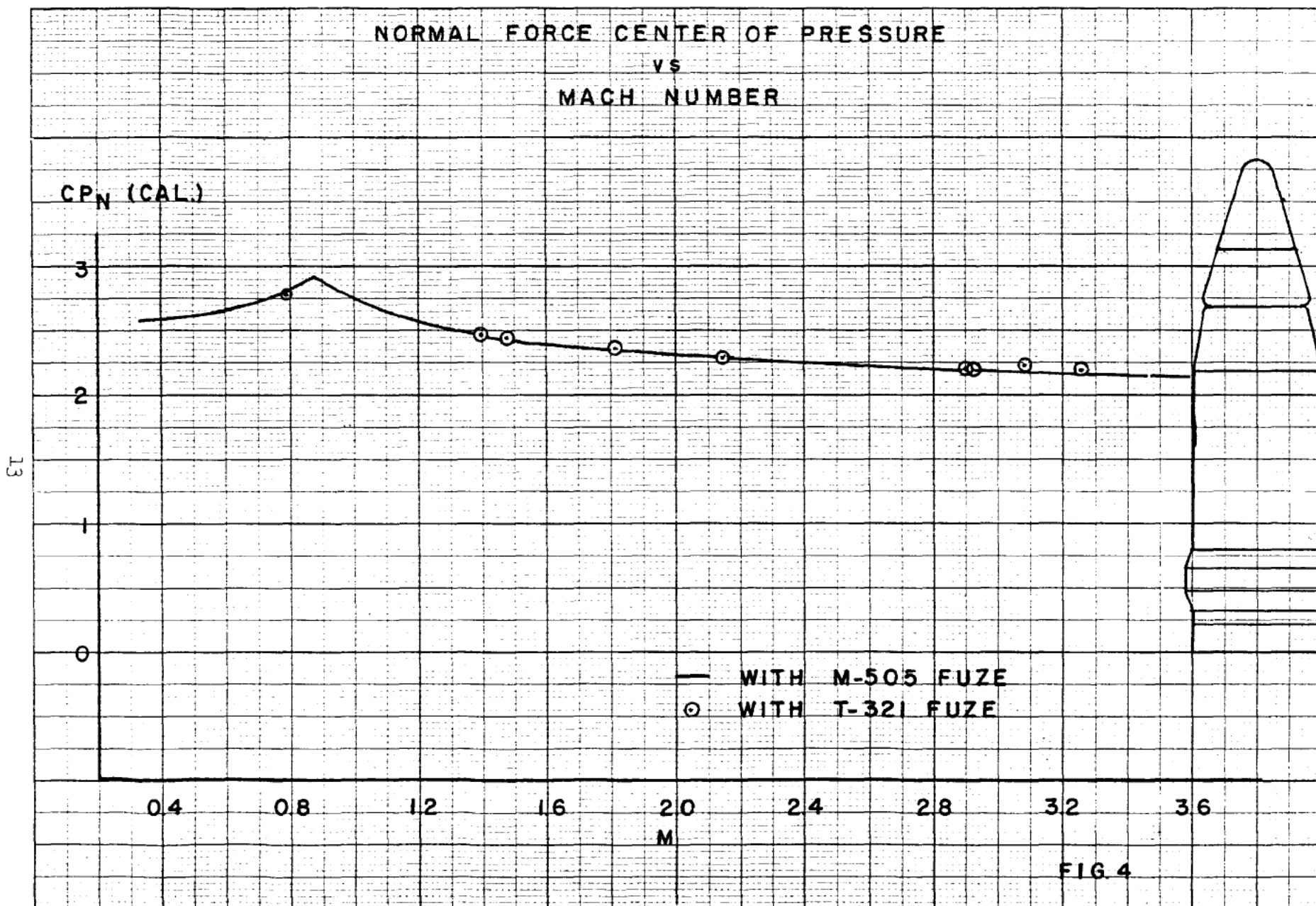


FIG. 3



MAGNUS MOMENT COEFFICIENT
vs
MACH NUMBER

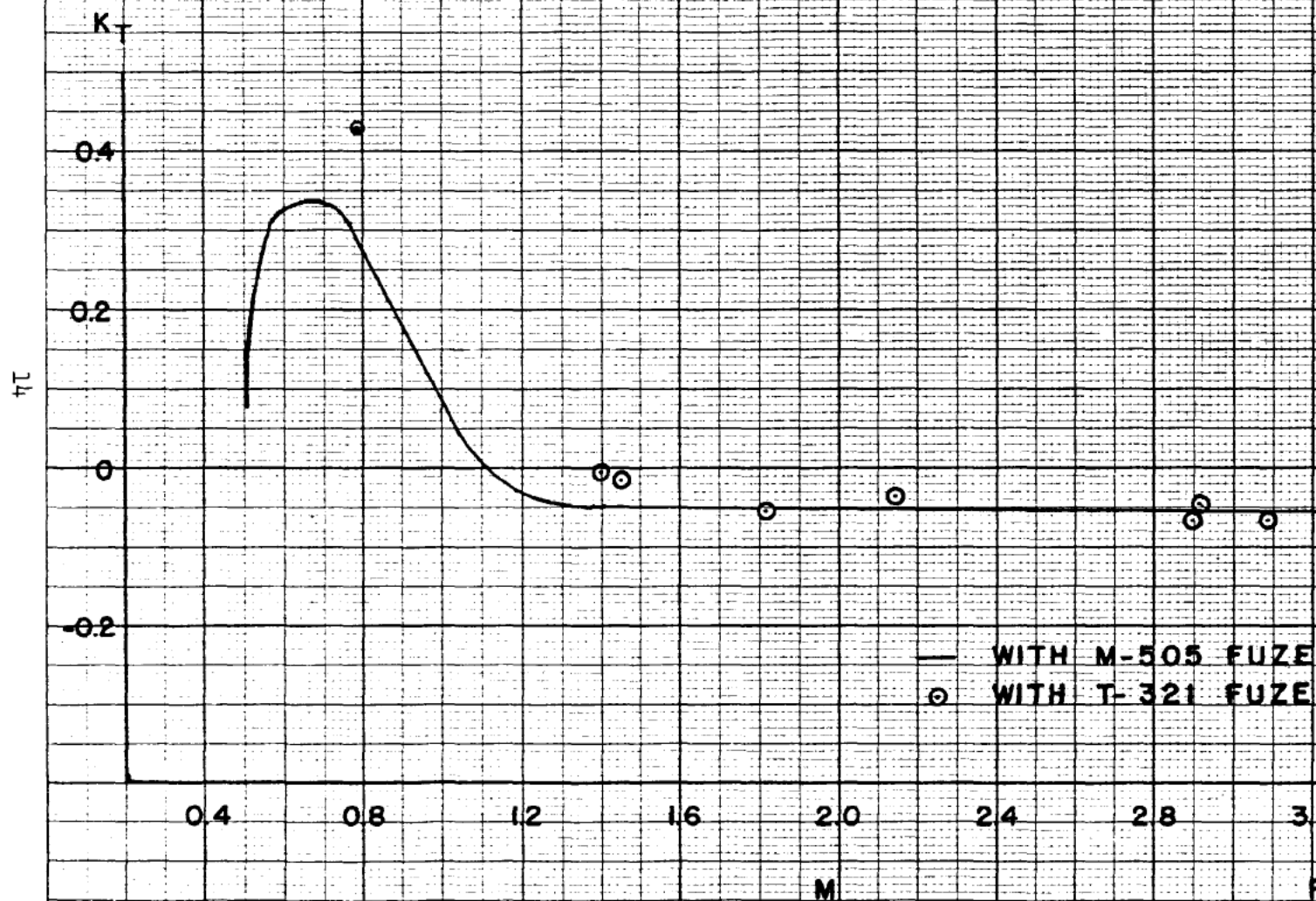


FIG. 5

DAMPING COEFFICIENT vs MACH NUMBER

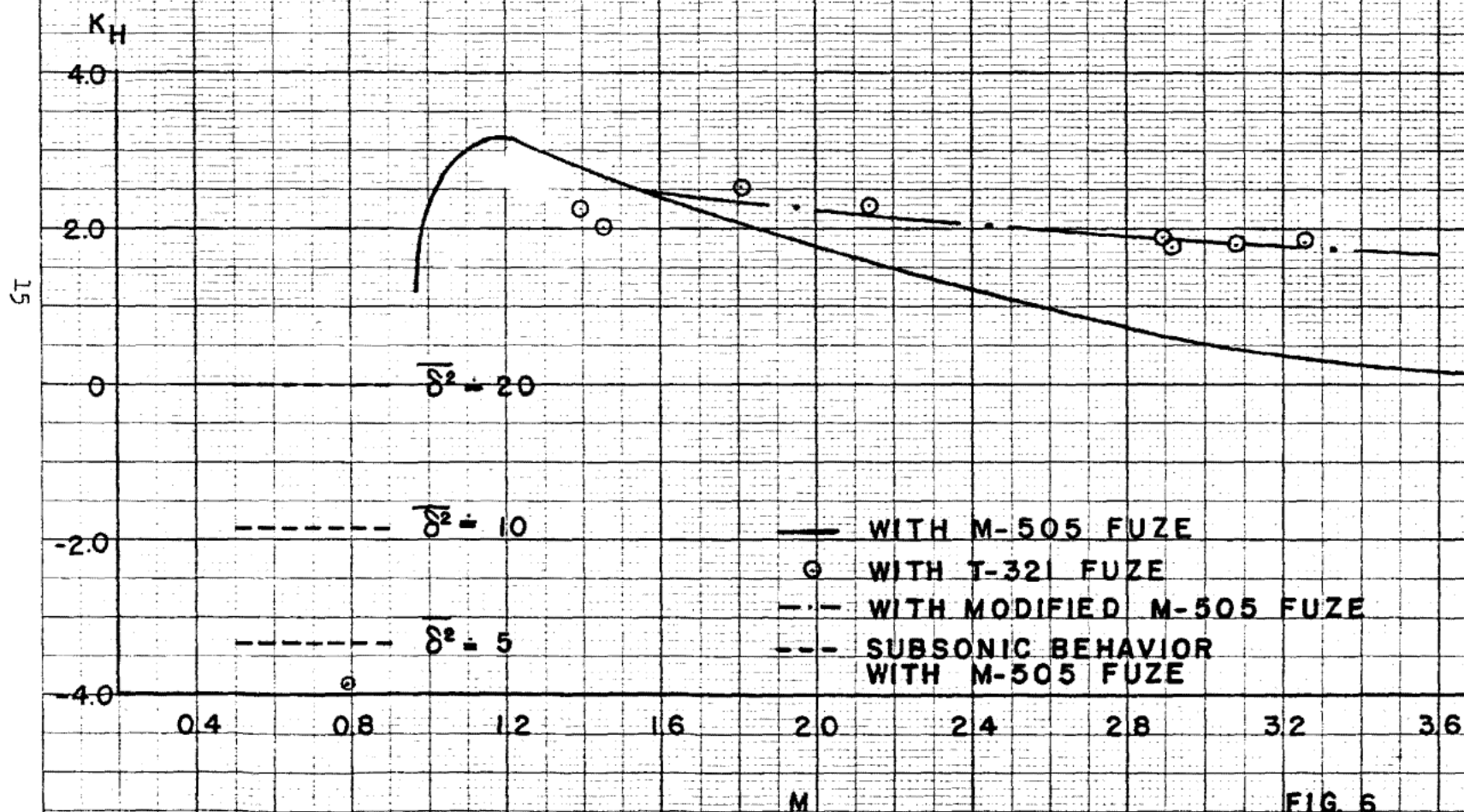


FIG 6

NUTATIONAL YAW DAMPING RATE VS MACH NUMBER

$\lambda_1 \times 10^3 \text{ FT}^{-1}$

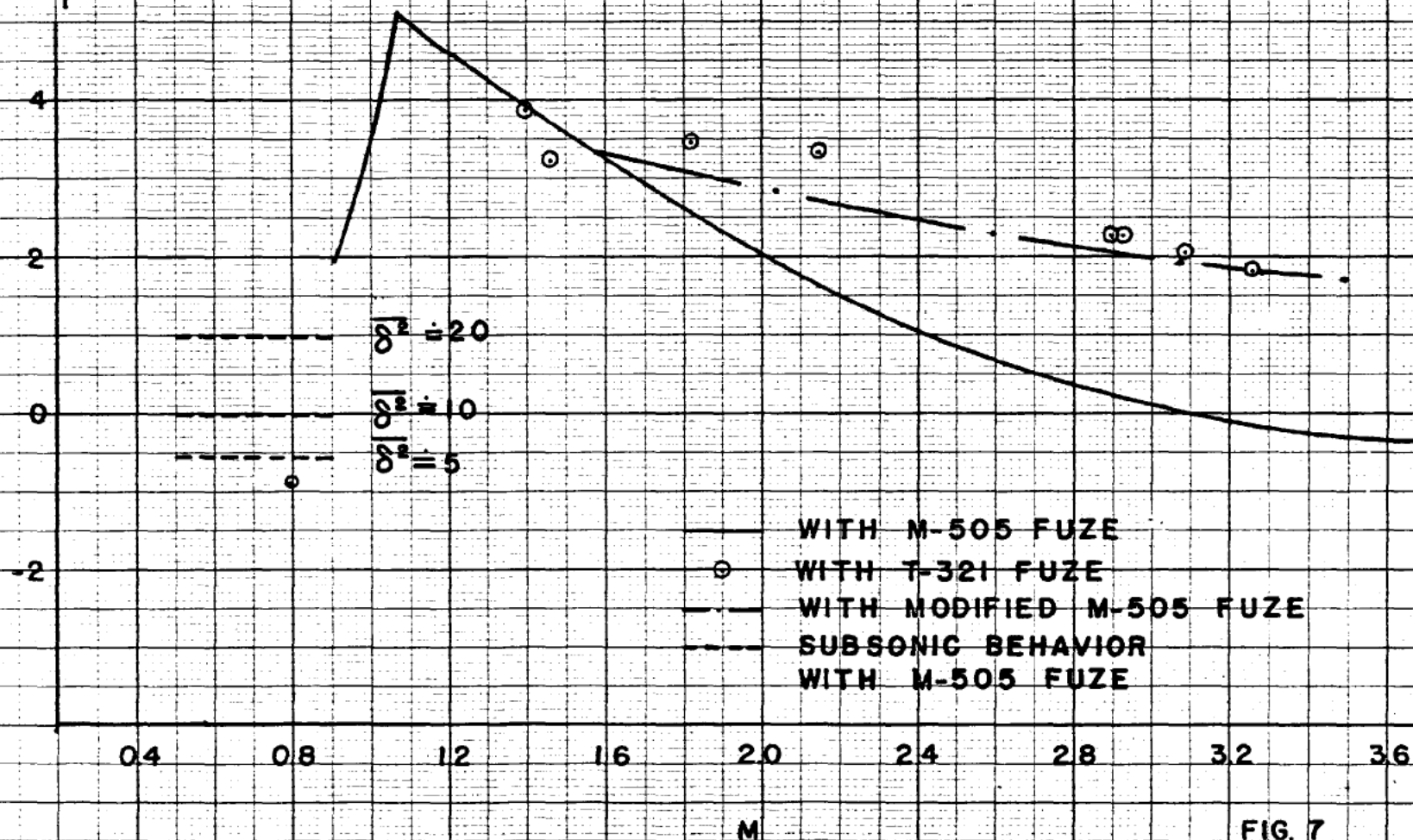
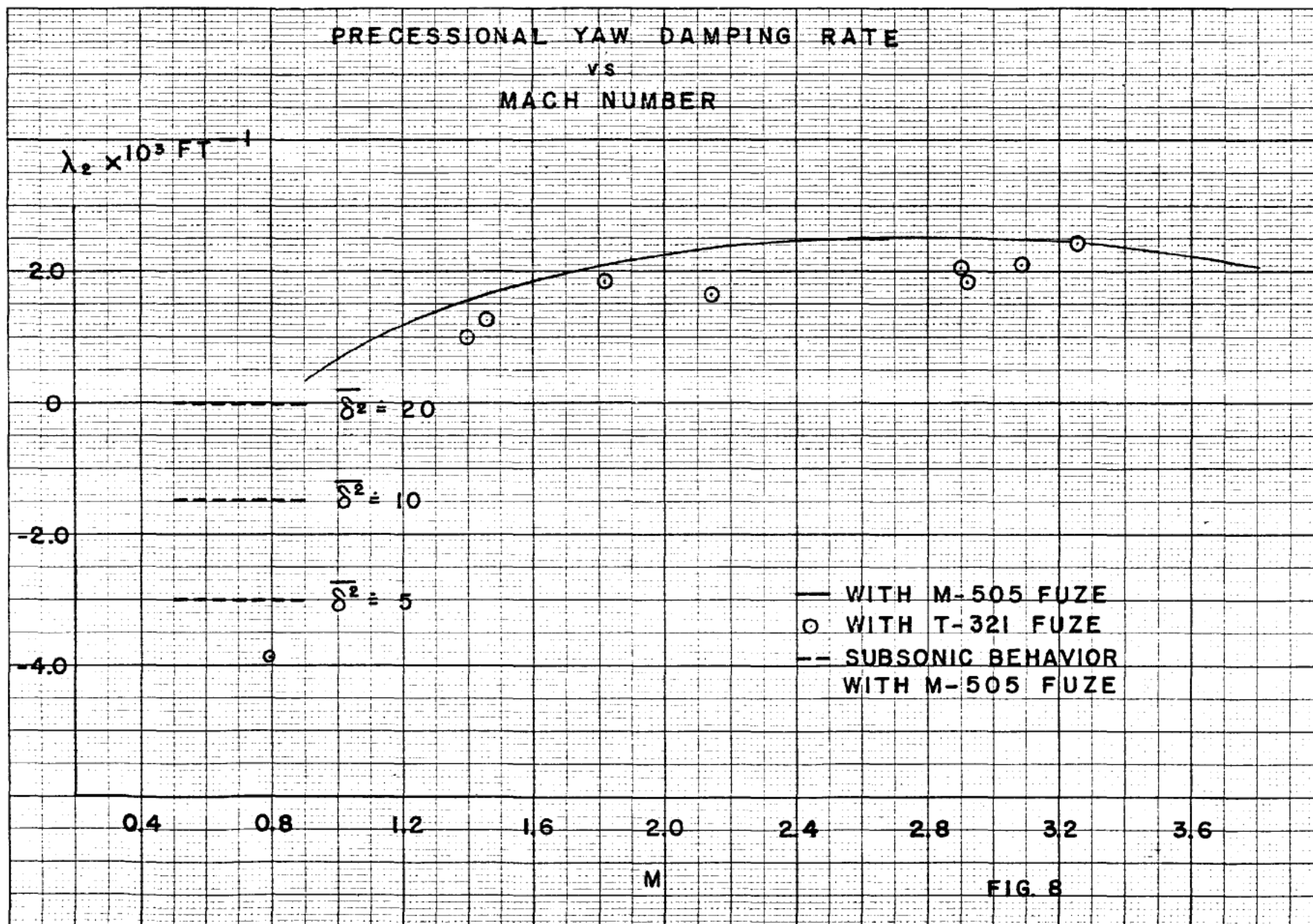


FIG. 7



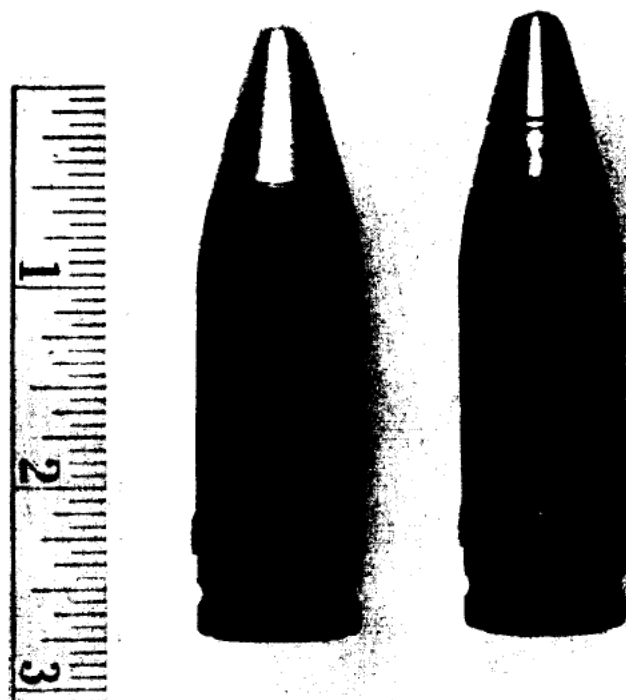


PLATE 1. Photograph of Shell
Left: M505 Fuze
Right: T321 Fuze

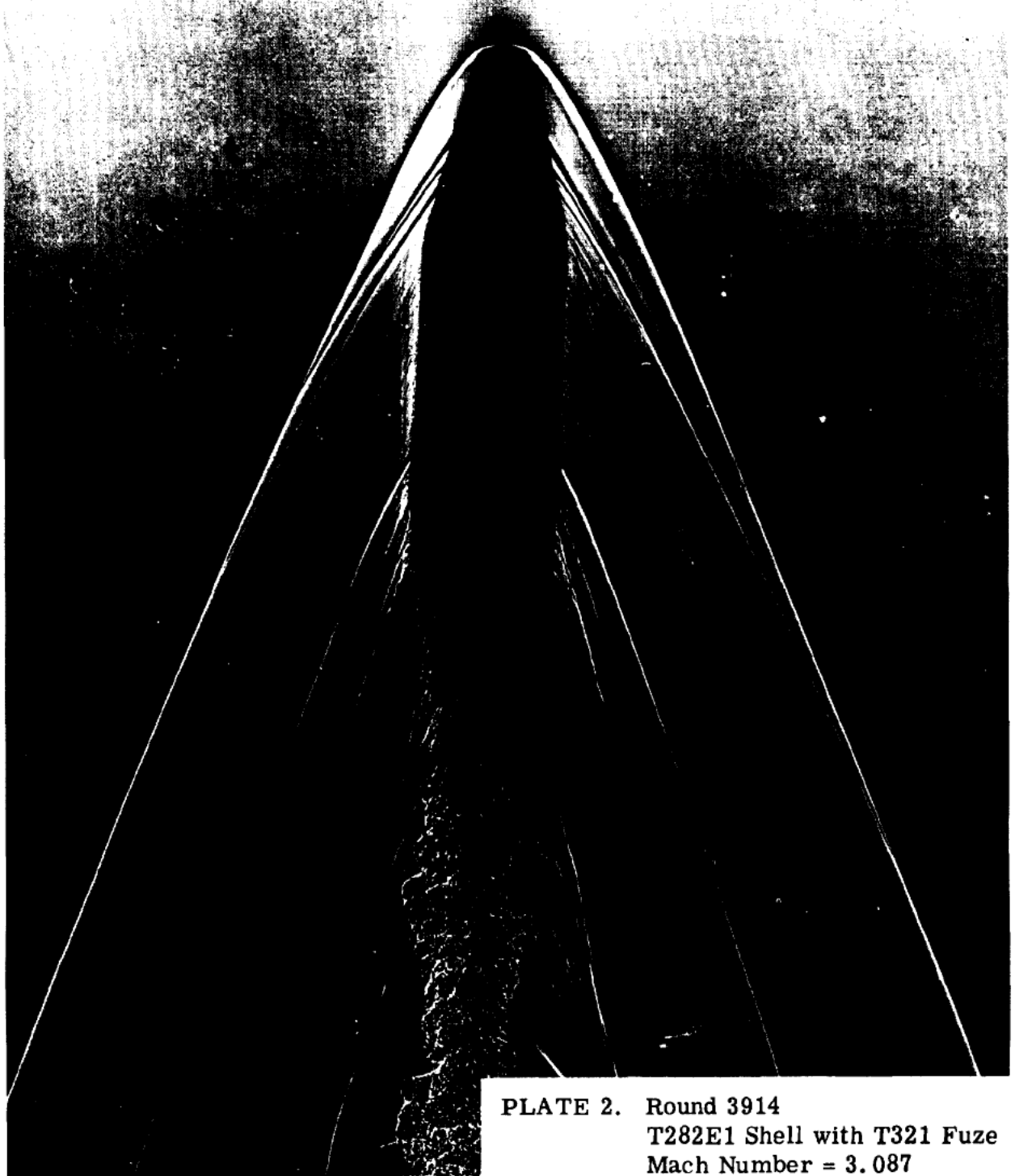


PLATE 2. Round 3914
T282E1 Shell with T321 Fuze
Mach Number = 3.087

DISTRIBUTION LIST

<u>No. of Copies</u>	<u>Organization</u>	<u>No. of Copies</u>	<u>Organization</u>
	Chief of Ordnance Department of the Army Washington 25, D. C. Attn: ORDTB - Bal Sec	15	Commander Air Force Armament Center Air Munitions Development Laboratory Wright Air Development Center Wright-Patterson Air Force Base, Ohio Attn: WCUG ACUB ACUR
10	British Joint Services Mission 1800 K Street, N. W. Washington 6, D. C. Attn: Mr. John Izzard, Reports Officer	5	Commander Air Force Armament Center Eglin Air Force Base, Florida Attn: ACOT
4	Canadian Army Staff 2450 Massachusetts Ave. Washington 8, D. C.		
3	Chief, Bureau of Ordnance Department of the Navy Washington 25, D. C. Attn: Re3	1	Commander Arnold Engineering Development Center Tullahoma, Tennessee Attn: Deputy Chief of Staff, R&D
2	Commander Naval Proving Ground Dahlgren, Virginia	1	Commander USAF Fighter Weapons School Nellis Air Force Base, Nevada Attn: Lt. M. A. Cobra
2	Commander Naval Ordnance Lab. White Oak Silver Spring, Md. Attn: Mr. Nestingen Dr. May	5	Director Armed Services Technical Information Agency Documents Service Center Knott Building Dayton 2, Ohio Attn: DSC - SA
1	Commander Naval Air Development Center Johnsville, Pennsylvania		
2	Commander Naval Ordnance Test Station China Lake, California Attn: Technical Library	1	Director National Advisory Committee For Aeronautics Ames Laboratory Moffett Field, California Attn: Dr. A. C. Charters Mr. H. J. Allen

DISTRIBUTION LIST

<u>No. of Copies</u>	<u>Organization</u>	<u>No. of Copies</u>	<u>Organization</u>
1	National Advisory Committee for Aeronautics Lewis Flight Propulsion Laboratory Cleveland Airport Cleveland, Ohio Attn: F. K. Moore	1	Aerophysics Development Corporation P. O. Box 657 Pacific Palisades, California Attn: Dr. William Bollay
3	National Advisory Committee for Aeronautics Langley Memorial Aeronautical Laboratory Langley Field, Virginia Attn: Mr. J. Bird Mr. C. E. Brown Dr. Adolf Busemann	2	A. C. Spark Plug Division General Motors Corporation 1925 E. Kenilworth Place Milwaukee 2, Wisconsin Attn: Mr. H. Davis
		2	Arma Corporation 254 36th Street Brooklyn, New York
1	Commanding General Frankford Arsenal Philadelphia 37, Pennsylvania	1	Consolidated Vultee Aircraft Corporation Ordnance Aerophysics Lab. Daingerfield, Texas Attn: Mr. J. E. Arnold
3	Commanding General Picatinny Arsenal Dover, New Jersey Attn: Samuel Feltman Ammunition Labs.	1	Cornell Aeronautical Lab., Incorporated Buffalo, New York Attn: Miss Elma T. Evans, Librarian
1	Commanding General Redstone Arsenal Huntsville, Alabama Attn: Technical Library	1	Crosley Division Avco Manufacturing Corp. 2600 Glendale Milford Road Box 116 Evandale, Ohio
2	Armour Research Foundation Illinois Institute of Technology Technology Center Chicago 16, Illinois Attn: Mr. W. Casier Dr. A. Wundheiler	1	Consolidated Vultee Aircraft Corporation Division of General Dynamics Corporation Fort Worth, Texas
2	Applied Physics Laboratory Silver Spring, Maryland Attn: Mr. George L. Seielstad	1	Emerson Electrical Manufacturing Company 8100 W. Florissant Avenue St. Louis 21, Missouri Attn: Mr. G. Hauser

DISTRIBUTION LIST

<u>No. of Copies</u>	<u>Organization</u>	<u>No. of Copies</u>	<u>Organization</u>
1	General Electric Company 1 River Road Schenectady, New York Attn: Mr. J. C. Hoffman	2	Sperry Gyroscope Co. Division of the Sperry Corp. Great Neck, L. I. New York
1	Glenn L. Martin Co. Baltimore, Maryland Attn: Mrs. Mary Ezzo, Librarian	1	United Shoe Machinery Corp. Balch Street Beverly, Massachusetts Attn: Mr. R. S. Parker
1	General Mills, Inc. 1620 Central Avenue Minneapolis 13, Minnesota	1	United Aircraft Corp. Research Department East Hartford 8, Connecticut Attn: Mr. C. H. King
1	Lockheed Aircraft Corp. Factory "A" Burbank, California	1	University of Michigan Willow Run Research Center Willow Run Airport Ypsilanti, Michigan Attn: Mr. J. E. Corey
1	McDonnell Aircraft Corp. P. O. Box 516 Municipal Airport St. Louis 1, Missouri	2	University of Texas Box 8036, University Station Austin 12, Texas
1	M. W. Kellogg Company Foot of Danforth Avenue Jersey City 3, New Jersey Attn: Miss E. M. Hedley	1	Wright Aeronautical Corp. Wood-Ridge, New Jersey Attn: Sales Department (Government)
2	Massachusetts Institute of Technology 68 Albany Street Cambridge 39, Massachusetts Attn: Lt. Col. C. N. DeGennora	1	Westinghouse Air Arm Division Friendship International Airport Baltimore, Maryland
2	Northrop Aircraft, Inc. Department 3483 Hawthorne, California Attn: Mr. D. C. Olmore		
2	North American Aviation, Inc. 12214 Lakewood Boulevard Downing, California Attn: Mr. Jim Elms		